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WEAR-RESISTANT METAL ALLOY

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This invention relates to wear resistant metal composition, the object being to secure a metal suitable for the making of the various types of wear resistant parts such as lathe centers, plug gauges, burnishing tips, internal gauges, ring gauges, rest plates and other various elements or devices utilized in a position subject to considerable wear and by such wear resistant metal secure long life in the machines or devices equipped therewith or formed thereof.

The purpose of the invention therefore is to secure a very compact and a highly wear resistant metal comprising an alloy of several metals that is capable of taking a high polish to provide a glass-smooth wearing surface. Of such hardness as not to be readily marred or worn through frictional contact with any of the usual metals employed in the manufacture of the various parts as, for instance and not by way of limitation, a vanadium steel shaft rotatable on a lathe or grinding machine center formed of my improved wear resistant alloy.

In the manufacture of machine tools and the various parts of the automobile and other machines and devices, the metals utilized as the machine art has developed are being made of higher grade materials and usually of a greater hardness. To keep pace with this development, a materially higher grade of wear resistant material is required. For instance, the centers in lathes for the turning of high grade steel elements are rapidly worn away and thus are of short life requiring constant replacement. Also, plug gauges as another instance need to be very accurate and if made of metals heretofore utilized are readily worn and soon become inaccurate requiring replacement.

This invention therefore seeks to provide a composite metal of a character of composition and method of manufacture thereof to secure a wear resistant metal of improved characteristics.

These and various other objects and features of the invention are hereinafter more fully described and claimed.

My improved wear resistant metal is composed of the following elements alloyed together—namely, tungsten carbide, nickel, molybdenum and chromium in the proportions hereinafter stated.

The function of each of the elements of the composition is as follows:

The tungsten carbide containing 6 per cent carbon is the base metal and produces the desired hardness and resistance to wear.

Nickel is used as a binding element inasmuch as the temperature at which the metal is formed liquefies the nickel which alloys with the tungsten carbide.

The molybdenum provides toughness and desired tensile strength and forms a ternary alloy with the nickel and tungsten.

The chromium is utilized as a de-oxidizer.

The above enumerated elements are the essential elements of my improved wear resistant metal but it is pointed out that a small proportion of other elements or components may be utilized such as boron, silicon, tantalum, antimony, manganese, titanium, vanadium or zirconium. Either one or the other of these may be added to the base composition to secure certain additive characteristics as for instance, an increased hardness and/or density.

The proportion of the base metals may vary inasmuch as there are many places of use where an extreme hardness is not desirable and a composition for use where a lesser hardness is required and thus the percentages of the metals may be varied to produce articles of different degrees of hardness and wear resistance.

As an example of the possible variation in the percentages of the base metals, I herewith give the preferred percentages of metals from the least hardness to the greater hardness.

HARD	HARDER	HARDEST
80–20 mix	*85–15 mix*	*90–10 mix*
WC___77.0%	WC___81.7%	WC___86.5%
Ni____19.2%	Ni____14.4%	Ni____ 9.6%
Mo___ 2.8%	Mo___ 2.9%	Mo___ 2.9%
Cr____ 1.0%	Cr____ 1.0%	Cr____ 1.0%

The elements in any of the suggested percentages are first reduced to a very fine powder and thoroughly mixed by ball milling for a period of from eighty to one hundred and twenty hours or more until the composition is of such a fineness as to pass a 400 mesh screen. The ball milling is to be performed in an atmosphere free from oxygen and moisture. The powdered material is then placed in a mold and tamped and then submitted in the furnace to reducing atmosphere for a period of one to four hours, depending largely upon the size and nature of the piece to be formed. In order that the mass may be of uniform density and free from voids, the material is then placed in a resistance type of furnace such for instance as is shown in my Patent 2,074,038, granted Mar. 16, 1937, in which there is a plunger that may enter the mold to engagement with the material and in which the crucible lies between the electrodes of the fur-

nace. A lever is utilized to operate the tamp and a gauge for indicating the pressures (not here shown). The material under pressure of the tamp is submitted to heat, the pressure then reduced and the material allowed to cool and this heating under pressure and cooling is best performed in a series of steps in which the pressure is increased step by step from an initial pressure of approximately 10,000 pounds to a final pressure of about 20,000 pounds per square inch and in which the temperature is increased step by step from 900 degrees C. to in the neighborhood of 1750 degrees C.

The material is submitted to heat and pressure increased in degree at each step and cooled therebetween and is important in that in the initial step, the air and gas formed through the heating of the material are gradually driven off so that at least in the final step if not before, the material is practically entirely freed from the gases and even minute voids are prevented. The interval of cooling is not so important as to temperature change as it is to provide time interval permitting the gases to escape and the temperature drop is usually less than 200 degrees F. The time interval required for such drop in temperature is sufficient to permit the gases to discharge prior to the final step. The small percentage of chromium is included as one of the base materials, its purpose being to free the materials of oxygen. Also, in the original steps, the material is not at alloying temperature and is porous and by cooling between the successive applications of heat and pressure gives opportunity for development of the gases within the body which in subsequent steps are eliminated from the material by the pressures and thus at the final temperature of 1350 to 1750 degrees C., at which the metals will alloy, there is no air, gas or oxygen present in the body of the material or that will develop therein under the alloying temperature. It is these steps of the heating under pressure and cooling in succession that are productive of greater density of the mass and as the principal ingredients, tungsten, nickel and molybdenum form a ternary alloy, I secure a metal that is not only of an extreme hardness but one that will take a high polish and provides a metal that is to an unusual degree wear resistant adapting it for the various uses as hereinbefore mentioned.

It will also be observed from the preceding list of possible compositions that a considerable variation may be made in the percentages of the materials—that is, the amount of tungsten may vary from approximately 76 to 87 per cent, the nickel being of about 20 per cent for the lower amount of tungsten and correspondingly decreasing to about 9 per cent for the higher amount of tungsten while the molybdenum and chromium may be practically constant throughout the range of tungsten or nickel percentages. It is therefore to be noted that the nickel decreases in percentage as the tungsten is increased and the range in percentage of the tungsten and nickel given will provide a wear resistant metal of the desired properties of hardness and wear resistance as may be required for a specific use. The metal in any of the precentages given has practically the same density and varies only in hardness. It is also capable of taking a very high polish so that the metal is useable as a light reflecting surface. The metal is considered practically black but, due to the ingredients, is more properly described as a dark grey. It has a metal sheen and due to the fineness and density, a polished surface is capable of reflecting light without distortion.

As previously suggested, additional elements such as boron, silicon, antimony and the like may be used to secure a somewhat greater hardness and compactness or density and the percentages of such additive elements may be as high as 10 per cent of the total volume.

Elements such as boron, vanadium and the like have a tendency to increase the hardness and antimony, for instance, has a tendency to produce a greater density and in the event any such elements are utilized in the compositions as set forth in the preceding tables, a correspondingly less percentage of tungsten and a slightly less percentage of nickel may be used, the percentage of nickel relative to the tungsten being practically the same as in the tables. Nickel is the preferred component for use with tungstein but a metal of the iron group, such as cobalt, may be utilized and an additive element such as antimony may be used as such element tends to lower the temperature at which the metals will alloy.

Having thus fully described my invention, its utility and mode of operation, what I claim and desire to secure by Letters Patent of the United States is—

1. A wear resistant metal comprising the following compositions in percentages by weight to total 100 per cent—namely, a tungsten carbide containing approximately 6 per cent carbon within the range of 76 to 87 per cent, nickel within the range of approximately 20 per cent to 9 per cent, molybdenum—approximately 2.8 per cent, and chromium—approximately 1 per cent, the molybdenum and chromium being practically constant in percentage throughout the entire range of percentages of tungsten carbide and nickel.

2. A wear resistant metal alloy formed of the following ingredients, viz.—a 6 per cent tungsten carbide within the range of approximately 76 to 87 per cent, nickel in the range of 20 to 9 per cent, molybdenum 2.8 per cent and chromium—approximately 1 per cent, the molybdenum and chromium being practically constant in percentages through the range of percentages of the tungsten and nickel, the materials in finely powdered form having been submitted to heat and pressure and providing a very dense, smooth surfaced, alloy free from voids and having a glass smooth surface.

3. A wear resistant metal alloy comprising the following ingredients in percentages by weight to total 100 per cent—namely, a 6 per cent tungsten carbide within the range of approximately 76 to 87 per cent, nickel correspondingly within the range of 20 to 9 per cent, molybdenum 2.8 per cent, chromium approximately 1 per cent, a small percentage of titanium for increasing hardness, and a small percentage of antimony having the characteristic of lowering the temperature at which the mass will alloy.

4. A wear resistant metal alloy comprising the following ingredients in percentages by weight to total 100 per cent—namely, a 6 per cent tungsten carbide within the range of approximately 76 to 87 per cent, a nickel correspondingly within the range of 20 to 9 per cent, molybdenum 2.8 per cent, chromium approximately 1 per cent, and titanium up to 10 per cent.

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